Coating Fabrication Issues

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Pipeline Coatings

The role of external pipeline coatings is to complement cathodic protection systems in protecting pipelines from corrosion and subsequent failure
Demands

- Improved pipeline integrity
- Improved coating performance.
  - increased reliability
  - less risk of failures
  - longer expected lifetime
  - less maintenance
- Improved quality
- Increased capabilities
  - higher pipeline operating temperatures
  - low temperature construction in arctic regions
- Environmental concerns
- Improved life cycle economics
  - material costs
  - construction & operating costs

Strategy for Achieving Pipeline Integrity

- Develop understanding of coating performance requirements
- Design and select coatings properly
- Ensure meaningful specifications are written
- Apply coating under optimum process with adequate quality control
- Carry out construction according to plan
- Operate system within specification
- Periodic monitoring and feedback on performance
- Research & Development of new technologies
Requirements

CSA Z662:
- 9.2.7.1 properties: coating shall
  - a) electrically isolate the external surface of the piping from the environment;
  - b) have sufficient adhesion to effectively resist underfilm migration of moisture;
  - c) be sufficiently ductile to resist cracking;
  - d) have sufficient strength and adhesion - to resist damage due to soil stress and normal handling (including bending, concrete coating application, river/swamp weight installation, and anode bracelet installation, where applicable);
  - e) be compatible with cathodic protection;
  - f) resist degradation of the coating properties throughout - conditions and temperatures encountered during storage, shipping, construction, and operation;
  - g) where plant-applied and applicable to the coating system to be used, be in accordance with CSA standard Z245.20 or Z245.21

Matching Coating Properties to Integrity Issues

<table>
<thead>
<tr>
<th>HANDLING</th>
<th>INSTALLATION</th>
<th>TESTING</th>
<th>OPERATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loading/Stacking</td>
<td>Stringing</td>
<td>Hydrostatic expansion</td>
<td>Temperature Environment</td>
</tr>
<tr>
<td>Transportation</td>
<td>Bending</td>
<td>Extensibility</td>
<td>Oxidative stability</td>
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<tr>
<td>Environmental Exposure</td>
<td>Burial</td>
<td>Penetration resistance</td>
<td>Tensile strength</td>
</tr>
<tr>
<td>Impact strength</td>
<td>Abrasion resistance</td>
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<td>Compressive strength</td>
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<tr>
<td>U.V. Resistance</td>
<td>Shear strength</td>
<td>Penetration resistance</td>
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### Plant Coating Technologies

- **Powder Applied Coatings**
  - FBE
    - Single layer: corrosion and specialty
    - Multi-layer: abrasion, anti-slip, protective topcoat
  - HPCC
    - Multi-component: FBE, adhesive, PE or PP topcoat
- **Extrusion Applied Coatings**
  - 2 layer PE/PP
    - Mastic adhesive, butyl, hot melt
  - 3 layer PE/PP
    - FBE, adhesive, PE or PP topcoat
- **Liquid Applied Coatings**
  - Polyurethane, epoxy, coal tar enamel, asphalt enamel

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### Fusion Bonded Epoxy

![Diagram of Fusion Bonded Epoxy](image)

- **Powdered Epoxy**
- **Steel Pipe**
  - **FBE Base Coat**
  - **FBE Top Coat**
  - **FBE**
  - **DPS FBE**
The GLOBAL LEADER in Pipe Coating Solutions

**HPCC**

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<th>Material</th>
<th>Standard Thickness</th>
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<td>Black MPDE topcoat</td>
<td>500 micron (20 mils)</td>
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<td>FBE/Adhesive Interlayer</td>
<td>125 microns (5 mils)</td>
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<tr>
<td>FBE</td>
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</tr>
<tr>
<td>TOTAL</td>
<td>750 microns (30 mils)</td>
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1. Black MPDE Topcoat
2. FBE/Adhesive Interlayer
3. FBE Primer
4. Steel Pipe

**2 Layer PE/PP**

- Adhesive
- Top Coat
- Steel Pipe
**3 Layer PE/PP**

- Topcoat
- Epoxy Primer
- Steel Pipe
- Copolymer Adhesive

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**Field Coating Technologies**

- **Powder Applied Coatings**
  - FBE
    - Single layer
    - Multi-layer
    - Multi-component
      - FBE, adhesive, PE or PP topcoat
- **Liquid Applied Coatings**
  - Polyurethane, epoxy
- **Heat Shrink Sleeves**
  - Crosslinked PE/PP with/out liquid epoxy
- **Others**
  - Tapes, sleeves, etc.
Heat Shrink Sleeve

1. Adhesive Directly To Line Coating
2. CrossLinked Backing
3. Force Cured Epoxy System
4. Pre-attached Closure System
5. “Open” Adhesive Technology
6. Epoxy On Steel Only

Typical Process

PIPE IN

PREHEAT
Establishes uniform initial pipe temperature

SURFACE PREPARATION
Removes mill scale
Establishes anchor pattern

INSPECTION
Verify pipe suitable for coating
Ensure there are no mill scale or cracks
Inspect weld profile
Promotes coating adhesion to steel
Removes soluble salts, i.e. chlorides

ADDITIONAL SURFACE TREATMENT
Promotes coating adhesion to steel
Removes soluble salts, i.e. chlorides

HOLIDAY INSPECTION/STENCILING
Remove water from pipe interior
Holiday detection
Coating thickness measurement
Apply stencil
Tally pipe
Smooth cutbacks and bevels

COOLING
Remove heat from pipe and coating

COATING APPLICATION
Electrostatic powder spraying
Extrusion
Liquid spraying

PRE-HEAT
Pre-heats pipe to application temperature

PIPE OUT
FBE Coating Process

Design & Selection

Need better understanding of performance requirements to quantify and select
Many studies on various properties, for example:
  • Impact
  • Shear adhesion
  • Thermal aging
  • UV degradation
  • Cathodic disbondment
  • Cathodic protection
Buried Pipeline Stress Analysis

Pipeline Stress Analysis
OD 762mm wt 16.4mm - Burial Depth 2m - Gas filled

FBE thickness vs Stockpile time

Outdoor exposure time (months)
Coating thickness remaining (microns)

FBE A
FBE B
Specifications

- Need for standardization
  - Proliferation of company exclusive specifications
  - Many differences, some good, some bad
  - ISO standards being developed
- Need for performance based specifications
  - Define performance requirements not manufacturing process
  - End result can be to stifle innovation, build in mediocrity with poor specifications
- Need for meaningful specification
  - More requirements, tighter criteria not often better
  - Focus on important properties and limits
  - Can deteriorate into testing project

Manufacturing Issues

- Complex application process
  - Many diverse processes to apply coatings: from heating, surface preparation, materials application
- Little consensus on best process/parameters
  - Some research on various parameters such as profile, contamination, surface treatments
  - Studies often not very conclusive
- Realistic expectations
  - Large heavy part/surface area to be coated
  - Process time limitations (delivery schedules)
  - Cost limitations as % of steel cost
  - Cannot treat in same manner as small components
Surface Preparation

- Most important process in determining coating quality
- Need to determine optimum parameters and how to measure during process
- Many companies do not understand importance
- Some coatings are more sensitive to level of preparation

Optimum Blast Profile?
Cross-head/side extrusion?

Manufacturing Issues

- Not ideal manufacturing process
  - Cannot schedule, inventory management, etc.
- More similar to project driven business
  - Customer supplied pipe
  - Wait for pipe to be delivered and then coat
- Problems inherent to project driven industries
  - Inefficient if work is not steady
  - Issues on maintenance of skilled labour
Incoming Pipe Quality

- May not be critical for pipeline itself but important for processing and coating application
- Condition of pipe on delivery
  - Wall thickness
  - Roundness
  - Camber
  - Weld profile
  - Steel cleanliness
  - Contamination
  - Joint length
- Steel pipe specification
  - Need to address not only pipeline design issues but also subsequent ability to process for coating

Quality Assurance

- Should be internally driven by coating applicator
  - Customer should expect a high level QA program
- Quality improvement programs
  - Awareness
  - Preventative
  - Inspection and audit
- Use of ISO 9001
  - Program regularly audited by third party
Industry Feedback is Important

- Assessment of coating performance in independent digs
- Confirmation of predictive analysis on long term coating properties
  - Adhesion
  - Permeability
  - Material properties
- Joint development of corrective strategies
- Operators, contractors, coaters, regulators, and engineering companies need to work as a team

Failure Modes

- Damaged Coating
  - Impact damage
  - Cracking
  - Deterioration
- Shielding Disbondment
  - Over the ditch tapes
- Permeable Coating
  - Asphalts and to some extent FBE
- Blistered Coating
  - Has been observed with FBE
- Disbondment
  - Has been observed with 3 layer PE and PP coatings
Blistered FBE

3LPE Disbondment
2LPE Cracking

Tape Disbondment & Wrinkling
Research

- Predictive studies
  - Predictive analysis of properties (long term)
  - Relation of lab measured properties to field performance
  - Development of models to use in design & selection of coatings
- Product/process development
  - New products to reduce failures, increase performance, increase reliability, lower cost
  - Standards need to be flexible to allow new developments
- Failure Analysis
  - Understanding coating failures
    - Blistering
    - Disbondment
    - Cracking

Competitive Issues

- Protection of innovative technologies
  - Patents, secrecy agreements
- Limits to access
  - Conflicts with end users specifying full access
- Intentional and accidental sharing of technologies
- Protection of R&D investment
Summary

- Design & selection of coatings
- Specification changes
  - ensure steel pipe is compatible to coating process
  - performance based
- Research
  - Develop design & predictive methodologies
  - Feedback of actual coating performance in service
  - New materials and processes to increase performance, reliability and reduce life cycle cost
- Competitive industry
  - Protection of innovative technologies
  - Payback of R&D investment